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Student Notes
Science on Saturday
Lawrence Livermore National Laboratory
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CSU Fresno

Our Universe: Watch Out!

Dr. Wil van Breugel
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Goal:

Students will learn how scientists are learning about the violent universe and the formation of galaxies, stars, planets, and ultimately us.

Questions:

What questions were posed by Dr. van Breugel that you should know at the end of this presentation?

Question – 1

How do stars and planets form?

Question - 2

What are some of the dangers to planets, including Earth?

Question - 3

How do galaxies get larger?

Question - 4

What happens when galaxies collide?

Question - 5

What are active black holes?

Question - 6

What can happen when jets collide with interstellar gas?

California Content Standards

This lecture, "Our Universe: Watch Out!" supports the following standards:

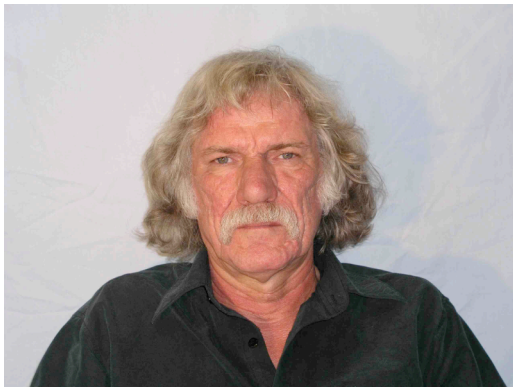
Earth Science Standards: Grades 9-12: Earth Sciences, Earth's Place in the Universe

1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:
 - a. Students know how the differences and similarities among the sun, the terrestrial planets, and the gas planets may have been established during the formation of the solar system.
 - b. Students know the evidence from Earth and moon rocks indicates that the solar system was formed from a nebular cloud of dust and gas approximately 4.6 billion years ago.
 - c. Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.
 - d. Students know the evidence indicating that the planets are much closer to Earth than the stars are.
 - e. Students know the Sun is a typical star and is powered by nuclear reactions, primarily the fusion of hydrogen to form helium.
 - f. Students know the evidence for the dramatic effects that asteroid impacts have had in shaping the surface of planets and their moons and in mass extinctions of life on Earth.
 - g. * Students know the evidence for the existence of planets orbiting other stars.
2. Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time. As a basis for understanding this concept:
 - a. Students know the solar system is located in an outer edge of the disc-shaped Milky Way galaxy, which spans 100,000 light years.
 - b. Students know galaxies are made of billions of stars and comprise most of the visible mass of the universe.
 - c. Students know the evidence indicating that all elements with an atomic number greater than that of lithium have been formed by nuclear fusion in stars.
 - d. Students know that stars differ in their life cycles and that visual, radio, and X-ray telescopes may be used to collect data that reveal those differences.
 - e. * Students know accelerators boost subatomic particles to energy levels that simulate conditions in the stars and in the early history of the universe before stars formed.
 - f. * Students know the evidence indicating that the color, brightness, and evolution of a star are determined by a balance between gravitational collapse and nuclear fusion.
 - g. * Students know how the red-shift from distant galaxies and the cosmic background radiation provide evidence for the "big bang" model that suggests that the universe has been expanding for 10 to 20 billion years.

Related Links

- <http://marsrovers.jpl.nasa.gov/home/> (*Spirit/Opportunity Mission to Mars*)
- http://www.nasa.gov/mission_pages/cassini/main/index.html (*Cassini-Huygens Mission to Saturn*)
- http://map.gsfc.nasa.gov/m_mm.html (*Wilkinson Microwave Anisotropy Probe (WMAP) -- The First Detailed Full Sky Picture of the Oldest Light In the Universe*)
- <http://www.stsci.edu/resources/> (*Space Telescope Science Institute -- Home of the Hubble Telescope*)
- <http://www.spitzer.caltech.edu/Media/mediainages/index.shtml> (*Spitzer Space Telescope Homepage*)
- <http://www.galex.caltech.edu/> (*Galaxy Evolution Explorer Homepage*)
- <http://chandra.harvard.edu/pub.html> (*Chandra X-Ray Observatory Homepage*)
- <http://www.nrao.edu/imagegallery/php/level1.php> (*National Radio Astronomy Observatory Image Gallery*)
- http://www.noao.edu/image_gallery/ (*National Optical Astronomy Observatory Image Gallery*)
- <http://www.gemini.edu/index.php> (*Gemini Observatory Homepage*)
- <http://www.eso.org/outreach/gallery/astro/> (*European Southern Observatory Photo Gallery*)

Biography



Wil van Breugel, Ph.D.

**Research Astronomer
Institute of Geophysics and Planetary Physics
Lawrence Livermore National Laboratory and
Adjunct Professor in the School of Natural
Sciences at UC Merced**

Wil van Breugel has more 25 years of experience in conducting astronomical research using a wide variety of telescopes on earth and in space. He obtained his Ph.D. at Leiden Observatory, The Netherlands, where he discovered that some galaxies exhibit strong radio emission, which is powered by jets emanating from massive black holes at their centers ('radio galaxies'). After his Ph.D. he held postdoctoral fellowships at the Kitt Peak National Observatory and the University of Arizona's Steward Observatory in Tucson, Arizona. During that time he used the Kitt Peak 2.1-m and 4-m and Steward 2.5-m telescopes, as well as the world's most powerful radio imaging telescope, the National Radio Astronomy Observatory Very Large Array near Socorro, New Mexico. By combining radio and optical observations he found that radio jets often interact violently with gas clouds in the interstellar medium of their parent galaxies. Shocks from jet/cloud collisions heat up and entrain this previously invisible, cold gas. The heated gas can be observed on large telescopes using special filters.

After his postdoctoral years Wil became a research astronomer at the University of California at Berkeley. In collaboration with astronomy graduate students he used the Lick Observatory 3-m telescope for a systematic study of the optical properties of radio galaxies. This resulted in the discovery that the optical and radio emission from radio galaxies are closely aligned due to outflow from the jets and radiation from hidden, active black holes ('quasars') interacting with surrounding material. This interaction might in some cases even trigger star formation along the path of the jets.

Approximately 15 years ago Wil joined LLNL as a research astronomer at the Institute of Geophysics and Planetary Physics. He is now using the world's largest optical, twin 10-m telescopes of the W. M. Keck Observatory in Hawaii as well as the Hubbles Space Telescope, the Spitzer Space Telescope, and the Chandra X-ray Observatory to study the formation and evolution of the most massive galaxies and clusters of galaxies in the early Universe. Since 2004 Wil is also Adjunct Professor in the School of Natural Sciences at UC Merced, where he participates in teaching astronomy and astrophysics in a general education course.

Register at the LLNL Science and Technology Education Program (STEP) web site to receive updates of education programs for students and teachers: <http://education.llnl.gov/signup>